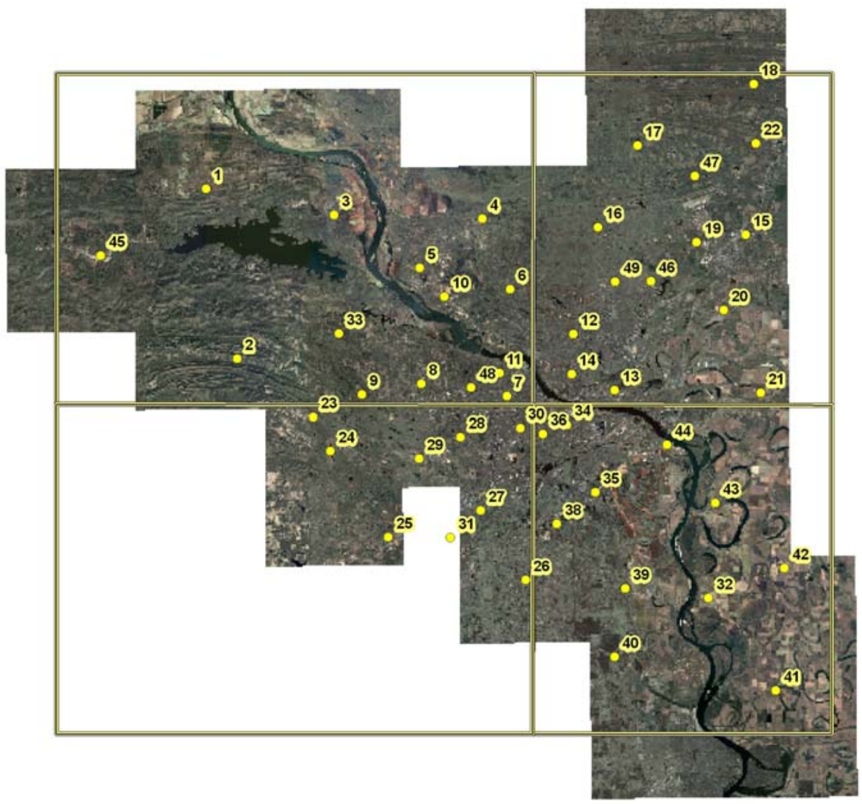
Pulaski County Arkansas
Digital Ortho Quarter Quadrangle (DOQQ)
Digital Globe GeoTiff Image Catalog

National Standard for Spatial Data Accuracy Report

11/15/2004



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Background

The Arkansas Geographic Information Office coordinated a cooperative DigitalGlobe purchase for Pulaski County, Arkansas. This purchase was made possible with funding provided by city, county, state, federal, and private participants. Funding participants included United States Geological Survey, MetroPlan, Pulaski County Arkansas and the Arkansas Department of Emergency Management.

The final deliverables included two-foot resolution, pan fused, color, digital ortho quarter quads. FGDC compliant metadata for each digital ortho quarter quadrangle was a component of the contract and was being delivered.

The DOQQ's were purchased under an "open" license agreement that enables distribution of the product via the State of Arkansas geospatial data clearinghouse- GeoStor (anticipated to be loaded by January 1, 2005).

Abstract
The Federal Geographic Data Committee (FGDC) established the National Standard for Spatial Data Accuracy (NSSDA) in 1998. The NSSDA provides a “statistical and testing” methodology for reporting the accuracy of vector and raster graphics. These methodologies enable one to compare the coordinates of an independent data set to the coordinates of the test data set to determine the horizontal or vertical accuracy of the test data set. This document will examine the horizontal accuracy of an ArcGIS image catalog consisting of GeoTiffs. The independent data set was created utilizing Global Positioning System technologies. The test data set was created by heads-up digitizing points on the DOQQs. Reporting the accuracy of spatial data following a common methodology allows end users of the spatial data to determine its usefulness.

Keywords
Accuracy assessment, digital orthophoto quarter quadrangle (DOQQ), Pulaski County, Arkansas, independent data set, National Standard for Spatial Data Accuracy, test data set

Definitions
Independent points (data set)- fixed positions collected utilizing Arkansas GPS Mapping Grade Standards, creating a data set of a higher degree of accuracy than the one being tested.

Test points- positions that could be visually interpreted on the DOQQ and in the field. These positions were compiled manually utilizing heads-up digitizing methodologies in ArcGIS 9x.

Purpose

1. Determine the accuracy of the Pulaski Digital Globe DOQQs
2. Demonstrate the proper use of NSSDA reporting methodologies

Accuracy Assessment

An accuracy assessment (AA) of the Pulaski County Digital Globe DOQQ's was conducted utilizing methodologies presented in the NSSDA (appendix I). The AA will provide those using the Pulaski County Digital Globe DOQQs with their known horizontal accuracy. This will insure that spatial data created utilizing the Pulaski County mosaic can be performed with known horizontal accuracies. This document will present the methodologies used while performing the AA on the Pulaski countywide DOQQs.

Results

The Pulaski County mosaic tested 3.6 meters (11.7 feet) horizontal accuracy at a 95% confidence level.

Location Pulaski County (shown in red) is located in north central Arkansas.

Figure 1

The area encompassed by Pulaski County is characterized as both rural and urban. A number of photo interpretable land cover is present, including: hardwood, softwood, agriculture, urban and hydrologic features. Pulaski County also has a considerable amount of terrain relief.

The Selection of Independent Points

The NSSDA provides guidelines for selecting independent points prior to performing fieldwork. During the pilot (Lewisville NW, May 15, 2001), it was observed that the NSSDA guidelines (appendix II) were difficult to follow due to vehicle accessibility in rural areas, and visual interpretation of the DOQQ. To this end a considerable amount of mission planning time was spent, prior to performing the fieldwork. Specific attention was given to the ability to interpret independent points and the accessibility to the predetermined sites.

Figure 2 illustrates the distribution of the independent points selected. A detailed description of each point is provided

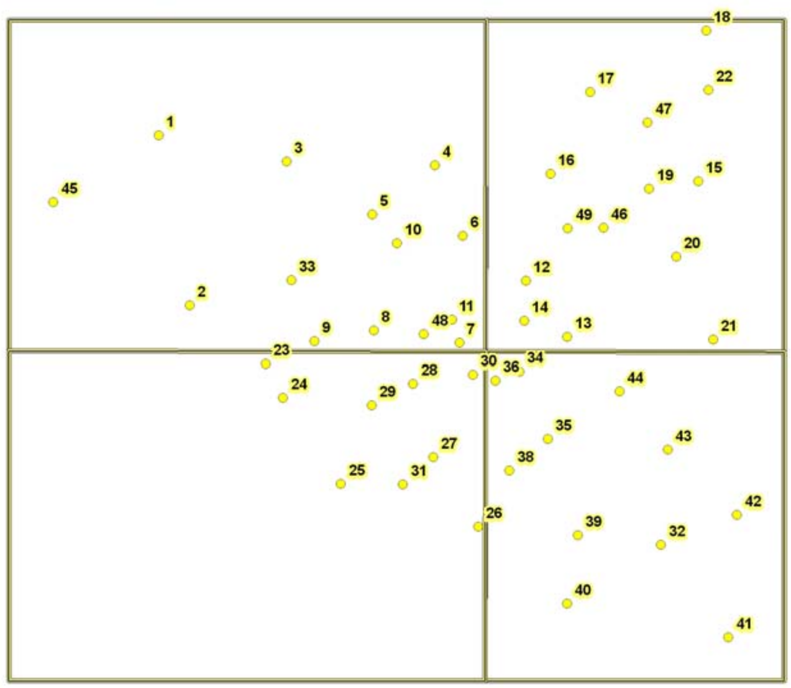

Figure 2

Developing Independent and Test Datasets

Utilizing ArcGIS 9 software, and Pulaski County DOQQ independent points were selected. Visually interpretable road intersections were reviewed. A general guide (cross-hair) was heads-up digitized at a scale of 1:1,200 (Figure 3).

Figure 3

A point was then placed in the center of converging crosshairs at a scale of 1:0 (Figure 4). The points manually placed on the mosaic served as the test data set.

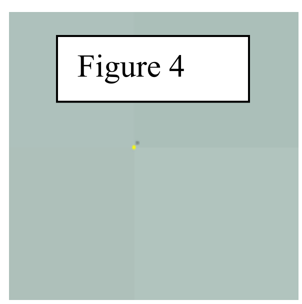

Figure 4

The coordinates for the independent points were acquired utilizing GPS methodologies and the Arkansas Mapping Grade GPS Standards. (Refer to appendix IV for metadata pertaining to the GPS methodologies employed.)

Collecting the coordinates for independent points in the field

Once all of the independent point coordinates were acquired, the data was transferred from a Trimble ProXR to the Trimble Pathfinder Office Software and then differentially corrected. The independent points were then exported from the Trimble Pathfinder Software to an ESRI™ shapefile, and viewed in ArcGIS 9. (Refer to appendix V for a complete listing of resources utilized.)

Determining the Difference

All test point ID numbers were compared to the unique id of the independent data set to ensure the two data sets had been properly attributed. Coordinates for the test data set were added to the attribute table of the shapefile utilizing the ArcGIS 9 Xtools (AR State Plane North Zone, NAD83, feet).

The coordinates obtained for the independent data set were real time or differentially corrected (refer to appendix IV), and exported from Pathfinder Office into an ArcView shapefile. Using the functionality of the Pathfinder software a number of attributes were included with the shapefile. (Refer to appendix VI.)

The coordinates from the test and independent datasets were copied into an NSSDA worksheet. Table 1 provides a detailed description of the information provided from the NSSDA worksheet.

Table 1

Item	**Description**
Point Description	unique id number represented in each of the data sets
X (independent)	x coordinate of point from independent data set
X (test)	x coordinate of point from test data set
Difference in X	x (independent) – x (test)
(Difference in X)^2	squared difference in x = (x (independent) – x (test))^2
Y (independent)	y coordinate of point from independent data set
Y (test)	y coordinate of point from test data set
Difference in Y	y (independent) – y (test)
(Difference in Y)^2	squared difference in y = (y (independent) – y (test))^2
(Difference in X)^2 + (Difference in Y)^2	squared difference in x plus squared difference in y equals (error radius)^2
Sum	sum of (Difference in X)^2 + (Difference in Y)^2
Average	sum divided by the number of points
Root Mean Square Error	RMSE (radial) = average ^{½}
National Standard for Spatial Data Accuracy	NSSDA statistic = 1.7308* RMSE

It is important to understand the results observed from the NSSDA test are not a function of good or bad spatial data. The NSSDA is only a statistical model intended to determine the spatial accuracy of the test data set to that of the independent data set. The NSSDA does not set a standard for what is to be considered accurate data. The end user of the spatial data should determine if the accuracy is acceptable for their project.

Analysis

Utilizing the NSSDA worksheet, the Pulaski County Digital Globe DOQQ image catalog tested 3.6 meters (11.7 feet) horizontal accuracy at a 95% confidence level (appendix VII)

USGS Standards for Digital Orthophotos, part 2.6 of the specifications, states "… DOQ's must meet National Map Accuracy Standards (NMAS) at 1:24,000 and 1:12,000 scale respectively. The NMAS specify that 90% of the well-defined points tested must fall within 40 feet at 1:24,000 and 33.3 feet at 1:12,000 scale"[3]. The Pulaski County Digital Globe DOQQs meet the USGS DOQ specifications.

Conclusion

Accuracy assessments performed following the NSSDA provide the end user of the geospatial data with known accuracies that follow a common methodology. The horizontal accuracy of the Pulaski County Data was found to be 4 meters (12 feet) at a 95% confidence level. ***This does not imply that all DOQQs have the same horizontal accuracy.*** The control points selected and the quality of the elevation model (data) for the area are major contributors to the accuracy of all DOQQs. NSSDA tests should be performed on each individual county mosaic or DOQQ when the spatial project requires known accuracies.

Appendix I- Selected Portion of the NSSDA (GeoSpatial Positioning Accuracy Standards Part 3)

*The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html

Federal Geographic Data Committee FGDC-STD-007.3-1998
Geospatial Positioning Accuracy Standards
Part 3: National Standard for Spatial Data Accuracy

3.2 Testing Methodology And Reporting Requirements

3.2.1 Spatial Accuracy

The NSSDA uses root-mean-square error (RMSE) to estimate positional accuracy. RMSE is the square root of the average of the set of squared differences between dataset coordinate values and coordinate values from an independent source of higher accuracy for identical points . [1] Accuracy is reported in ground distances at the 95% confidence level. Accuracy reported at the 95%confidence level means that 95% of the positions in the dataset will have an error with respect to true ground position that is equal to or smaller than the reported accuracy value. The reported accuracy value reflects all uncertainties, including those introduced by geodetic control coordinates, compilation, and final computation of ground coordinate values in the product.

3.2.2 Accuracy Test Guidelines

According to the Spatial Data Transfer Standard (SDTS) (ANSI-NCITS, 1998), accuracy testing by an independent source of higher accuracy is the preferred test for positional accuracy. Consequently, the NSSDA presents guidelines for accuracy testing by an independent source of higher accuracy. The independent source of higher accuracy shall the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.[2]

The data producer shall determine the geographic extent of testing. Horizontal accuracy shall be tested by comparing the planimetric coordinates of well-defined points in the dataset with [3] coordinates of the same points from an independent source of higher accuracy. Vertical accuracy shall be tested by comparing the elevations in the dataset with elevations of the same points as determined from an independent source of higher accuracy.

Errors in recording or processing data, such as reversing signs or inconsistencies between the dataset and independent source of higher accuracy in coordinate reference system definition, must be corrected before computing the accuracy value.

A minimum of 20 check points shall be tested, distributed to reflect the geographic area of interest and the distribution of error in the dataset. When 20 points are tested, the 95% confidence level [4] allows one point to fail the threshold given in product specifications.

If fewer than twenty points can be identified for testing, use an alternative means to evaluate the accuracy of the dataset. SDTS (ANSI-NCITS, 1998) identifies these alternative methods for determining positional accuracy:

* Deductive Estimate
* Internal Evidence
* Comparison to Source

3.2.3 Accuracy Reporting

Spatial data may be compiled to comply with one accuracy value for the vertical component and another for the horizontal component. If a dataset does not contain elevation data, label for horizontal accuracy only. Conversely, when a dataset, e.g. a gridded digital elevation dataset or elevation contour dataset, does not contain well-defined points, label for vertical accuracy only.

A dataset may contain themes or geographic areas that have different accuracies. Below are guidelines for reporting accuracy of a composite dataset:

* If data of varying accuracies can be identified separately in a dataset, compute and report separate accuracy values.

* If data of varying accuracies are composited and cannot be separately identified AND the dataset is tested, report the accuracy value for the composited data.
* If a composited dataset is not tested, report the accuracy value for the least accurate dataset component.

Positional accuracy values shall be reported in ground distances. Metric units shall be used when the dataset coordinates are in meters. Feet shall be used when the dataset coordinates are in feet. The number of significant places for the accuracy value shall be equal to the number of significant places for the dataset point coordinates.

Accuracy reporting in ground distances allows users to directly compare datasets of differing scales or resolutions. A simple statement of conformance (or omission, when a map or dataset is non-conforming) is not adequate in itself. Measures based on map characteristics, such as publication scale or contour interval, are not longer adequate when data can be readily manipulated and output to any scale or to different data formats.

Report accuracy at the 95% confidence level for data *tested* for both horizontal and vertical accuracy as:

Tested ____ (meters, feet) horizontal accuracy at 95% confidence level
____ (meters, feet) vertical accuracy at 95% confidence level

Appendix II- (GeoSpatial Positioning Accuracy Standards Part 3- Appendix 3-C)
*The complete document can be downloaded http://www.fgdc.gov/standards/status/sub1_3.html

Part 3: National Standard for Spatial Data Accuracy
Appendix 3-C (informative): Testing guidelines
Page 3-17

1. Well-Defined Points

A well-defined point represents a feature for which the horizontal position is known to a high degree of accuracy and position with respect to the geodetic datum. For the purpose of accuracy testing, well-defined points must be easily visible or recoverable on the ground, on the independent source of higher accuracy, and on the product itself. Graphic contour data and digital hypsographic data may not contain well-defined points.

The selected points will differ depending on the type of dataset and output scale of the dataset. For graphic maps and vector data, suitable well-defined points represent right-angle intersections of roads, railroads, or other linear mapped features, such as canals, ditches, trails, fence lines, and pipelines. For orthoimagery, suitable well-defined points may represent features such as small isolated shrubs or bushes, in addition to right-angle intersections of linear features. For map products at scales of 1:5,000 or larger, such as engineering plats or property maps, suitable well-defined points may represent additional features such as utility access covers and intersections of sidewalks, curbs, or gutters.

2. Data acquisition for the independent source of higher accuracy

The independent source of higher accuracy shall be acquired separately from data used in the aerotriangulation solution or other production procedures. The independent source of higher accuracy shall be of the highest accuracy feasible and practicable to evaluate the accuracy of the dataset.

Although guidelines given here are for geodetic ground surveys, the geodetic survey is only one of many possible ways to acquire data for the independent source of higher accuracy. Geodetic control surveys are designed and executed using field specifications for geodetic control surveys (Federal Geodetic Control Committee, 1984). Accuracy of geodetic control surveys is evaluated using Part 2, Standards for Geodetic Networks (Federal Geographic Data Committee, 1998). To evaluate if the accuracy of geodetic survey is sufficiently greater than the positional accuracy value given in the product specification, compare the FGCS **network accuracy** reported for the geodetic survey with the accuracy value given by the product specification for the dataset. Other possible sources for higher accuracy information are Global Positioning System (GPS) ground surveys, photogrammetric methods, and data bases of high accuracy point coordinates.

3. Check Point Location

Due to the diversity of user requirements for digital geospatial data and maps, it is not realistic to include statements in this standard that specify the spatial distribution of check points. Data and/or map producers must determine check point locations. This section provides guidelines for distributing the check point locations.

Check points may be distributed more densely in the vicinity of important features and more sparsely in areas that are of little or no interest. When data exist for only a portion of the dataset, confine test points to that area. When the distribution of error is likely to be nonrandom, it may be desirable to locate check points to correspond to the error distribution.

For a dataset covering a rectangular area that is believed to have uniform positional accuracy, check points may be distributed so that points are spaced at intervals of at least 10 percent of the diagonal distance across the dataset *and* at least 20 percent of the points are located in each quadrant of the dataset.

Appendix III- GPS Metadata

GPS Metadata

Type of receiver	Trimble ProXR
Accuracy of receiver as stated by manufacturer	sub meter
Approximate distance from the base station used for differential correction	5 K
Base station used for differential correction	University of Arkansas at Little Rock (SSF) 34 43 27.77488 N 92 20 27.06917 W Elevation 113.2 m HAE http://argis.ualr.edu/gis
Coordinate system	Geographic (lat/long)
Datum	WGS 84
Date of collection	10/25/2004
Differential correction applied	Real Time and Differential Correction
Elevation Model	Height above Ellipsoid
Minimum number of positions for point feature	60
PDOP Mask	Maximum of 6
SNR Mask	Minimum of 6
Unit of Measure	meter
Vertical accuracy as stated by manufacturer	meter

Appendix IV- Resources utilized while performing the NSSDA

- Trimble Pro XR
- Dell Inspiron Laptop
- Hand held compass
- ESRI™ ArcGIS 9.0
- Pulaski County mosaic (Mr. SID 20:1)
- Pathfinder Office software
- Pulaski County 9-1-1 Centerlines (used for orientation purposes)
- Hardcopy of the Pulaski County mosaic with pre-selected points overlaid
- Approximately 30 man-hours.

Appendix V- Attributes exported with the Independent data set

Shape	Date	Time
File_name	Picture name	Max_pdop
Corrected_type	Receiver Type	GPS-date
GPS_time	Feat_name	Datafile
Unfiltered_positions	Filtered_positions	Updated_station
Standard deviation	GPS_height	Horizontial_Precision
Vertical_Precision	Latitude	Longitude
Point ID	Data_dictionary	GPS_week
GPS_second		

Appendix VI- Horizontal Accuracy Worksheet Results from the NSSDA Test Performed on the Pulaski County Digital Globe DOQQ GeoTiff Image Catalog

A Point number	C x (independent)	D x (test)	E diff in x	F (diff in x)^2	G y (independent)	H y (test)	I diff in y	J (diff in y)^2	K (diff in x)^2 + (diff in y)^2
1	1125729.56	1125730.29	-0.73	0.54	215510.19	215513.72	-3.53	12.49	13.03
2	1134243.20	1134247.15	-3.95	15.59	165848.32	165851.42	-3.09	9.57	25.17
3	1162823.74	1162822.36	1.38	1.90	207511.32	207512.51	-1.19	1.42	3.33
4	1206001.64	1206003.23	-1.59	2.52	206027.38	206022.53	4.85	23.52	26.04
5	1187644.71	1187646.19	-1.48	2.18	191868.14	191863.18	4.95	24.55	26.73
6	1213853.92	1213854.49	-0.57	0.32	185357.91	185361.98	-4.07	16.57	16.90
7	1212524.70	1212525.23	-0.53	0.28	154242.42	154244.53	-2.12	4.47	4.75
8	1187709.96	1187706.98	2.98	8.87	158103.68	158109.06	-5.38	28.99	37.86
9	1170411.53	1170407.89	3.64	13.26	155081.21	155082.98	-1.77	3.14	16.40
10	1194712.76	1194713.90	-1.13	1.29	183347.30	183347.59	-0.29	0.08	1.37
11	1210421.26	1210421.58	-0.32	0.10	160876.02	160882.47	-6.46	41.68	41.78
12	1232045.49	1232043.20	2.29	5.26	172061.03	172062.81	-1.77	3.14	8.39
13	1243901.17	1243902.55	-1.38	1.90	155581.72	155584.93	-3.21	10.31	12.22
14	1231431.35	1231429.31	2.03	4.14	160465.34	160465.04	0.30	0.09	4.23
15	1282441.16	1282441.19	-0.03	0.00	200466.91	200468.68	-1.77	3.12	3.13
16	1239473.18	1239474.43	-1.25	1.57	203182.02	203188.47	-6.45	41.59	43.16
17	1251249.57	1251250.80	-1.23	1.51	226747.42	226753.83	-6.41	41.05	42.57
18	1285198.80	1285199.38	-0.58	0.34	244415.87	244414.59	1.29	1.66	1.99
19	1268140.37	1268145.19	-4.82	23.28	198546.12	198544.54	1.58	2.50	25.78
20	1275838.14	1275839.78	-1.64	2.69	178596.24	178589.32	6.93	48.01	50.70
21	1286330.23	1286337.81	-7.59	57.56	154426.01	154433.84	-7.83	61.33	118.88
22	1285626.40	1285633.26	-6.86	47.10	227050.14	227045.98	4.16	17.29	64.39
23	1156175.28	1156169.66	5.62	31.56	148771.10	148771.87	-0.77	0.60	32.16
24	1161114.90	1161104.40	10.50	110.15	138815.61	138819.07	-3.46	11.99	122.13
25	1177683.42	1177675.83	7.59	57.60	113669.59	113666.77	2.82	7.93	65.53
26	1217438.25	1217436.00	2.25	5.08	100789.84	100782.54	7.29	53.21	58.28
27	1204602.77	1204608.12	-5.35	28.64	121067.80	121058.67	9.13	83.40	112.05
28	1198954.91	1198946.71	8.21	67.33	142569.43	142570.98	-1.55	2.42	69.74

29	1186841.91	1186829.38	12.53	156.98	136461.34	136460.05	1.30	1.68	158.66
30	1216361.78	1216361.85	-0.07	0.00	145063.94	145068.75	-4.82	23.19	23.19
31	1195689.90	1195682.75	7.15	51.05	113219.52	113216.99	2.53	6.40	57.45
32	1270542.16	1270540.88	1.29	1.65	94934.46	94934.68	-0.22	0.05	1.70
33	1163830.26	1163838.03	-7.78	60.48	172892.64	172897.62	-4.98	24.78	85.26
34	1229867.26	1229868.44	-1.18	1.39	145790.89	145787.36	3.53	12.44	13.83
35	1237963.54	1237967.87	-4.33	18.78	126028.52	126020.76	7.76	60.22	79.00
36	1222899.98	1222900.41	-0.43	0.19	143207.31	143209.18	-1.87	3.49	3.67
38	1226711.46	1226713.69	-2.23	4.96	116972.94	116961.87	11.06	122.43	127.40
39	1246418.06	1246417.23	0.84	0.70	97930.62	97919.27	11.35	128.87	129.57
40	1243080.45	1243071.53	8.92	79.54	78099.79	78091.35	8.44	71.22	150.77
41	1289907.24	1289902.24	5.00	25.03	67880.84	67882.93	-2.09	4.35	29.38
42	1292725.36	1292722.06	3.30	10.86	103378.60	103380.53	-1.93	3.73	14.59
43	1272793.19	1272797.12	-3.93	15.45	122597.08	122596.48	0.61	0.37	15.81
44	1258972.45	1258980.04	-7.59	57.60	139727.59	139731.34	-3.75	14.08	71.68
45	1094896.79	1094890.04	6.75	45.50	196395.60	196391.82	3.78	14.27	59.77
46	1254763.77	1254762.29	1.48	2.18	187278.25	187284.27	-6.02	36.23	38.42
47	1267908.58	1267913.41	-4.83	23.35	217799.30	217801.10	-1.79	3.21	26.57
48	1202234.26	1202231.35	2.91	8.48	156811.18	156815.21	-4.03	16.26	24.74
49	1244417.72	1244416.01	1.71	2.92	187267.41	187274.28	-6.87	47.27	50.18
								sum	2210.33
								average	46.05
								RMSE	6.79
								NSSDA (feet)	11.75